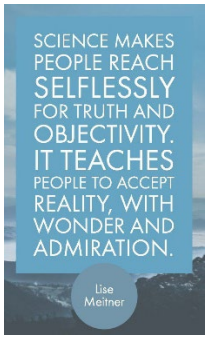

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XMaS Scientist Experience 2023

Launched in 2015, the XMaS Scientist Experience is a nationwide opportunity for any Year 12 female physics student to join Warwick University on an all-expenses-paid 4-day trip to the ESRFLink in Grenoble, France at the beginning of July 2023. Their aim is to encourage students to consider science careers, foster a sense of community, and encourage self-belief. Applicants need to be curious about the world around them, creative, and keen to learn more about science. Through this trip students are taken out of the classroom and shown science in a real-world application, with the aim of sparking an enthusiasm for the wonder of science.

In response, our very own L6 female physicist, Emma Sarkies, took up the challenge and was tasked with researching and writing a two-page essay on 'Lise Meitner; her life and contributions to science'. The competition had a record number of entrants this year. Sadly, Emma did not win the trip, but she did write an excellent article which we wanted to share with our readers.

Please write a two-page essay on:

Lise Meitner; her life and contributions to science.

Lise Meitner was born in Vienna, Austria, on November 7th, 1878, to Phillip Meitner, a lawyer and chess master, and Hedwig Skovran, a musician. Meitner enjoyed maths from a young age, with her father hiring a private tutor so that she could explore the subject more. Other hobbies of hers included playing the piano and reading. Meitner explained that ever since she was a young child, her parents gave her the mentality to think for herself about how and why the world works as it does. Meitner's mother would tell her and her seven siblings, "listen to your father and me, but think for yourself." Meitner was no longer able to continue her education in a grammar school after the age of fourteen, because beyond this point only male students were accepted in Vienna's grammar schools in the 1800s. She therefore remained at home and practiced her hobbies, but soon realised that she was missing her education. She would go on to discuss with her father the idea of continuing her education by studying for a science degree at the University of Vienna. Although her father didn't oppose the idea, he did suggest that she got a teaching qualification before going to university, with the hope that she would be better respected in this male dominated environment with the additional qualification. So, she did. She studied for a teaching qualification in French, which she completed at the age of 21, in 1899. After this, her father then hired her a private tutor so that she could prepare for the university entrance exam, allowing her to pass in the summer of 1901, aged 22.

Beginning her studies at the University of Vienna in October 1901, Meitner decided to specialise in physics. She worked incredibly hard to understand all the new concepts that Ludwig Boltzmann, who taught the majority of her classes, introduced to her, and this ultimately broadened her understanding of physics significantly. In December 1905 she passed her doctoral oral exam with the highest honour and graduated from the University of Vienna in February 1906 with a PhD in physics. Meitner then began to teach physics in secondary schools, taking a high interest in radioactivity, doing research of her own in the evenings. She then reached out to Max Planck, a lecturer at the University of Berlin, asking if he would mind her attending his lectures for a semester. Planck allowed this, so Meitner's father agreed to pay her living costs whilst she attended the semester in Berlin.

Having arrived in Berlin, Meitner decided that it was radioactivity that she wanted to research. As this involved both physics and chemistry, she was required to work with each department. The physics department were very welcoming to her, with Max Planck even inviting her to some of his family parties. This was highly contrasted by the chemistry department, who did not like Meitner studying there because she was a woman. There was one chemist, however, who was more than happy to work with her, called Otto Hahn. Hahn himself had only recently joined the Berlin University's chemistry department, having previously worked with Ernest Rutherford in discovering new radioisotopes. Despite not being allowed to give Meitner any space in the laboratories of Berlin's Chemical Institute, Hahn saw Meitner's potential and instead set up some equipment in a small carpenter's workshop. It was here that they carried out their research together with this partnership between them lasting for years.

Due to her being a part of the physics department at Berlin University, Meitner was soon able to publish

Name: Emma
Sarkies

Lise Meitner; her life and contributions to science continued:

some of her own papers and some which were jointly in her and Hahn's name; one of which detailed the
discovery of a new radioisotope of the element actinium in 1908. In 1909, Meitner and Hahn made the discovery of radioactive recoil, meaning that when an atomic nucleus emits an alpha particle, it will recoil as though it is a gun which has just fired a bullet. They then proved that since a positively charged recoiling nucleus is attracted to the negative electrode, this technique could be used to produce elements of very high purities, with them being collected on the negative electrode.

Meitner then was paid to work as Max Plank's assistant from 1912 until in 1914, when World War One began. Meitner subsequently worked in hospitals, carrying out work with X-rays, so that they could be used to help wounded soldiers. However, in 1916, Meitner decided to return to her research, a passion which she found difficult to be separated from. In 1917, Meitner and Hahn discovered a new isotope of protactinium, which had a half-life of around 32,000 years – protactinium-231. This was the first isotope of protactinium which didn't have a half-life which was too short to be able to conclude much about the element. This new discovery therefore meant that extensive research could be done into protactinium's properties for the first time. It was this which was the catalyst to Meitner's first professional recognition for her work - the Berlin Academy's Leibniz medal, awarded to her in 1917. She then achieved something which had never been done before – she became the first ever female professor of physics in Germany. Meitner was defying all odds, being a woman in STEM and making such great contributions to science. She forced her way into the highly respected and authoritative jobs, which normally would have been an impossible feat for any woman at this time due to the gender stereotypes that were present in society.

Despite Meitner being nominated for both the Nobel Prize in physics and chemistry, she never won either. Hahn alone was awarded the 1944 Nobel Prize in Chemistry for the discovery of nuclear fission, even though Meitner had contributed a huge amount to this discovery, as it was Meitner, not Hahn, who realised that nuclear fission could be possible. Meitner and her nephew, Frisch, came up with the liquid drop model. This model visualised the possibility of heavy nuclei breaking down into smaller and lighter nuclei. She also then used Einstein's equation $E = mc^2$ to calculate that there was enough mass converted to energy to create a huge amount of energy during nuclear fission. Meitner and Frisch then published a paper about this realisation and told Hahn and Niels Bohr. This news spread very quickly; most scientists were doing their own research and experiments on this concept before the paper had even been published, meaning that neither Meitner nor her nephew ever got as much recognition as they deserved.

It is undisputable that Meitner was an incredible scientist, who pushed the boundaries of science, being a huge contributor in the discovery of protactinium-231 and nuclear fission. This is still used today in

nuclear power plants to generate electricity which many people's daily lives depend on; around 15% of
the UK's electricity is made through nuclear fission. As well as this, though, Meitner was also a huge
personality who carved the way for women into science. She defied the expectations of what could possibly have been thought attainable by society of any woman at the time and was a huge force bringing more acceptance of women into science, which I think was one of her greatest achievements,
and a huge legacy which can be held to her name.

Name: Emma
Sarkies

Much research conducted at XMaS 'might one day have some practical use' and 'could have great commercial applications'.

Why is it important to conduct research even when the useful outcomes are uncertain?

Use our 'The Power of X-Rays in Materials Science' publication (see website) to assist your response.

I think we must ask ourselves what the purpose of scientific research is. To create new technologies to improve the daily lives of many? To improve healthcare? To find a cure to illnesses currently classed as 'terminal'? To fuel a passion of science and to become one step closer to understanding how and why the world works as it does? If the last point applies to you, then maybe, even if the outcome is not what you were hoping for, every single scientific research experiment is useful, as we are still learning one more thing about the incredibly complex world in which we live. Obviously, should scientific research lead to a groundbreaking, innovative technology which is able to cure cancer, reverse climate change, or improve the quality of life for billions of people around the world, this would be the most desirable outcome. However, until we get to a point where this is the case, every 'failed' experiment brings us one step closer to these goals, which would otherwise be an impossible feat. It is this reason why I believe that scientific research is incredibly important, on whatever scale, as even if it seems a failure, as long as we learn from our mistakes or lack of understanding and process the data that we generate, we are still learning about the world around us and refining our understanding for future experiments. This in turn leads us one step closer to creating that groundbreaking technology. This, to me, makes every research project and every experiment important, however uncertain the outcome is.

As the XMaS Co-Director, Professor Tom Hase said, "Modern technologies are underpinned by advances in our knowledge and function of the materials of which they are made." This shows how our modern lives today are only as they are because of previous research. I therefore believe that scientific research is vital if we want to progress our technology and improve the quality and length of lives around the globe. This is because the point of scientific research is to discover new ways of creating an end result, and there is no point in doing the research if you already know the optimum way of achieving your goal. This means that the success rate of scientific research that is conducted having the desired outcome is inevitably incredibly low. However, without previous scientific research our lives would be nothing like they are today – if it hadn't been for Alessandro Volta, who invented the first battery in 1800, we may not have electrical devices, such as iPhones, laptops, cameras, etc. We also wouldn't have pacemakers, battery-run devices which send electrical pulses to the heart, helping to establish a more regular heartbeat. This is a lifesaving treatment for millions of people around the world. A treatment which wouldn't have been as it is without Volta's invention of the battery. My point from this is that when Volta invented the battery in 1800, he didn't do it with the intention of a lifesaving medical device being realised from his work, being created 158 years later, but his work created this grounding. This shows that science is constantly evolving, and that research may even create the foundations of unimaginable technologies for future generations even if the current outcome seems to not be what was hoped for.

It is evident that XMaS have many talented scientists who are conducting scientific research which could be groundbreaking. For example, Professor Markys Cain working as part of a team using piezo materials as a possible way to treat arthritis, which can be an incredibly limiting condition. Should a treatment be discovered, it would transform the lives of millions of people – ten million people in the UK alone currently have arthritis.

In conclusion, I believe wholeheartedly that research is critical, especially when the useful outcomes are uncertain, as it could unlock limitless possibilities that could change so many lives for the better and enrich our understanding of this complex world in which we live.

Name: Emma
Sarkies

Tell us about yourself, your interest in STEM and why you think this opportunity could benefit your future goals.

I am currently studying maths, physics, chemistry, and biology at A-level, having achieved grade 9s in all four of these subjects at GCSE. I hope to study Natural Sciences at university, with a focus on the physical sciences. I am interested in many areas of science, but have a special interest in mechanics, astrophysics, particle physics and physical chemistry. Once I have finished university, I'm not sure what I would like to go into but know that it will be science related!

I am currently a STEM ambassador for my school, which means that I promote the sciences to other pupils, and this takes place in various forms. My role as a STEM ambassador has allowed me to get involved in science in several ways, such as by helping with our Christmas Science Lecture, helping the physics department in our sixth form open day, and helping with science competitions which our school has held.

I have also been involved in many science and maths competitions, such as the UKMT maths challenges, Senior Physics Challenge, run by BPhO and the online biology challenge. This academic year I sat both the Senior Physics Challenge and the Senior UKMT paper and achieved a silver certificate in both.

I have developed my interest in science by reading books and articles to help deepen my knowledge and understanding of a range of scientific topics. Such books include 'Wonders of the Solar System and the Universe' by Professor Brian Cox and Andrew Cohen, and 'Vaxxers', a book written by Sarah Gilbert and Catherine Green which details how they contributed to the creation of the Oxford AstraZeneca Covid-19 vaccine. Having read so many interesting science books and articles has helped to broaden my scientific understanding significantly and has also made me realise just how interesting science is and how many areas of science there are to explore!

Finding many areas of science interesting can be a challenge because it makes it very difficult for me to know what I want to specialise in and delve into further. Should I be given the opportunity to go on this amazing trip, I believe that it would enhance my understanding of science immensely and be an incredibly fascinating experience. It would also give me an opportunity to see if there is any specific field of science introduced to me which really excites me and that I could take further, potentially helping me to decide what job to go into. Should this be the case, it really would be a life changing experience.

Besides science, I also enjoy sport and music. I love many sports but especially enjoy hockey and am a member of my local club. I am currently working towards my grade eight trombone and grade five piano as well as playing my trombone in a brass band of which I am a member. These are hobbies which I hope to continue to nurture throughout my life, but it is science that I find extremely fascinating and what I think will direct the course of my future.

I really hope that you consider me for a place on the trip, which could be the opportunity that I need to be immersed in science in action, and to show me and direct me to what it is that I could take further.
Thank you for reading my entry and for presenting me with this potentially life changing experience.